CHAPTER 5
QUALITY ASSURANCE

5.1 INTRODUCTION

The quality and applicability of PAMS data analysis results are directly dependent on the inherent quality of the raw data itself. Data assessment information, such as that obtained from precision and accuracy (P&A) checks and performance audits, provides valuable measures of the general quality of PAMS data submitted to AIRS. Although reporting organizations and EPA are employing increasingly rigorous validation measures to insure optimum data quality, errors still get through the system. Because of the serious implications PAMS analytical results convey, PAMS data users are advised to critically examine all data before undertaking analysis in earnest. In this chapter we will highlight some recent PAMS data quality assessment information and also illustrate some useful screening procedures being used to identify potential errors that could bias results.

5.2 DATA ASSESSMENT

The assessment function of PAMS quality assurance involves two key required components: the National Performance Audit Program (NPAP) and precision and accuracy (P & A) data. EPA's Quality Assurance guidance mandates that all data collected for regulatory or research purposes be of known and documented quality. The EPA uses the National Performance Audit Program to independently quality assure the PAMS monitoring data it is receiving and permanently storing on AIRS. Audits for the PAMS compounds were added to the NPAP in 1995. Proficiency studies undertaken prior to the NPAP audits provided input to the program. Precision and accuracy checks are required for all types of PAMS monitors (meteorological, ozone, nitrogen oxides, VOC, and carbonyl).

5.2.1 NPAP and Proficiency Studies

In 1993 and 1994, the U.S. EPA National Exposure Research Laboratory (NERL), formerly, the Atmospheric Research and Exposure Assessment Laboratory, conducted cooperative efforts with the 22 State and local agencies monitoring for the PAMS compounds. This cooperative effort involved intercomparison studies (proficiency tests) in which these agencies analyzed samples for the PAMS volatile organic (VOC) and carbonyl compounds and reported their results to NERL for comparison to the NERL certified concentrations. Over the two year period, a total of twelve proficiency studies were conducted, 6 for VOCs and 6 for carbonyls. NERL compiled the results from each agency, compared the results to those from the referee laboratory and reported the results of the comparison to all agencies. The mean, median, variance, and the difference from the referee laboratory's results were reported for each analyte. One of the goals of this cooperative effort was to develop performance limits for a nationwide audit program for PAMS measurement systems being initiated in 1995 (NPAP) which would be modeled after these proficiency studies. The intent was to set performance limits which were reasonable, i.e., limits encompassing at least 90 percent of the audit results. Due to reported instability problems, proficiency tests were not required for 2-methyl-1-pentene, alpha and beta pinenes, and isoprene. Table 5-1 shows the 90% probability limits computed from the composite data of these audits. A column displaying the computed average bias for each parameter is also included. Bias values outside the range -90% to +900% were excluded from the analysis.

As shown in the table, eleven of the fifty-one compounds had average biases exceeding ten percent. Note also that the upper and lower limits vary considerably from the allowable ±15% employed under NPAP guidance for the criteria pollutants (NO_2, O_3, etc). In fact, the “allowable” range (upper limit minus lower limit) exceeds 30% (the criteria pollutant “allowable” range) for every one of the parameters. Only one compound, Toluene, had 90% of its bias values within ± 20%. Therefore, based on these factors, EPA decided to use compound-specific limits in the 1995 NPAP PAMS VOC and carbonyl audits at the 90% probability limits shown in Table 5-1.

The NPAP’s goal is to provide audit materials and devices that will enable EPA to assessed the proficiency of agencies that are operating ambient monitors. All agencies operating designated PAMS VOC and carbonyl sites were required to participate in the 1995 NPAP. The first two VOC audits proceeded as planned; however, in the third audit, over half of the compounds were found to be unstable. Sporadic stability problems were noted in all three of the carbonyl audits performed in 1995. Since the data from the affected audits are questionable, no summary report for 1995 was issued. Any future reports summarizing the PAMS audit data will not include individual audits because the NPAP policy requires that individual data results remain confidential. The 1996 NPAP PAMS audits were temporarily suspended pending outcome of research into the 1995 problems. As a precautionary measure, EPA arranged for another performance audit for the 1996 ozone season providing VOCs in canisters. The NPAP was able to provide two carbonyl audits in 1996 (June and September). A more reliable method of spiking the cartridges was designed and audit results so far have been excellent. Lengthy study of the VOC stability problem has not revealed a definitive answer, although it is believed that the passification procedure used by the manufacturer may have caused the problem. The NPAP offered one audit for VOCs in 1996 (September) by using only the cylinders that remained stable over a 4-month period.,

5.2.2 Precision and Accuracy Data

Although precision and accuracy checks are required for all types of PAMS monitors, EPA has not yet issued guidance for conducting and reporting VOC P&A checks due to the significant number of target compounds and the non-trivial expense associated with either dual analysis of cylinder gas or operation of a collocated continuous GC/FID. EPA realizes the importance of data assessment information and is expending substantial resources researching the issue. Since guidance is pending, no VOC P&A data have yet been reported to AIRS. Many reporting organizations, however, utilize some form of P&A audits in their data validation protocol.

Because ozone and nitrogen dioxide (two parameters of interest in PAMS) are also criteria pollutants, a P&A policy has already been promulgated for them. EPA has established 95% probability limits (precision) of ± 15% for these two pollutants. Tables 5-2 and 5-3 show 1995 monitor summary P & A data for PAMS that monitor ozone and nitrogen dioxide. Table 5-2 shows the 95% probability limits of precision bias for PAMS ozone monitors and Table 5-3 shows the same for PAMS nitrogen dioxide monitors.

5.3 DATA VALIDATION

Within 6 months of the end of each quarterly reporting period, data from VOC measurement systems must be submitted to AIRS. Although data may be collected automatically, it is interpreted and entered into AIRS manually. Some common human errors observed in this data processing effort include incorrect units, misread formats, etc. Even after substantial pre-AIRS QA\QC procedures have been performed, a double check of the data is always good practice. QA is necessary to identify data errors before they are analyzed and possibly used for such policy decisions as determination of nonattainment of the standards, control technology, modeling, or trends.

5.3.1 Summary Statistics and Historic Precedence (Scatter Plots)

Time series plots are useful for locating unusually high changes in the data from one value to the next or long periods of constant or no change. Figure 5-1 is a 1994 time series plot of four species groups at Stafford, CT (Main et al., 1995). There is an easily identifiable drastic change along the paraffin plot around 5AM. An unidentified peak was misidentified as a paraffin.

Univariate statistics such as the mean, median, maximum and minimum values, are good starting points for detection of potential data problems. Figure 5-2 plots summary statistics for June, 1995 at the E. Hartford, CT and Stafford, CT PAMS sites including the 90th, 75th and 25th percentiles (Main et al., 1995).

Summary statistics can be turned into box plots to hint at the distribution and variability of the data. The dark line at the center of each box is the median, the 25th and 75th percentiles are at the ends of the box. The box plots in Figure 5-3 show that the NMOC concentrations varied widely at E. Hartford, CT and Stafford, CT sites during June, 1995 (Main et al., 1995).

5.3.2 Frequency Distributions

The cost of monitoring and calibration measurements are just two of the causes of missing data. Missing data will occur and must be considered. Each analysis should have minimum data completeness requirements. For mean values, a 75% completeness requirement is common. Missing data are simply ignored in most statistical analysis software. For examining trends or time series analysis, missing values should be estimated. See Appendix H of part 50 40 CFR for time series modeling techniques to fill in the missing values.

Side by side box plots display the number of hours each day reported for every species in Figure 5-4 (Cox, 1995). The dark line at the center of each box is the median number of hours reported each day. The 25th and 75th percentiles are at the ends of the shaded box. Values outside of the whiskers (the narrow areas extending from the box) are isolated dots. Except for the few measurements of relative humidity, the meteorological data is relatively complete. O_3, NO, NO_2, NO_X and CO are relatively complete compared to the other continuous pollutant measurements.

Figure 5-5 displays a matrix for the reported ethylene data by hour for each day during July, 1993 at the Maryland PAMS site (Cox, 1995). After the 4th, the data is relatively complete except for morning hours.

Figure 5-6 shows frequency distributions for total NMHC concentrations measured at the E. Hartford, CT PAMS site during June, 1995 (Main et al., 1995). Data collected from 1600-2000 were almost exclusively above 50 ppbC. Afternoons make up the majority of the 50-200 ppbC groups while morning hours are a large part of the > 250 ppbC groups. Different hour and ppbC groupings would yield different distributions. Note the left to right skewness of the “all data” frequency, yet the morning or early afternoon histograms would appear to be more bimodal.

5.3.3 Spatial & Temporal Plots

Spatial and temporal plots are graphical data views which readily show easily identifiable outliers such as in the next example. The ozone exceedance at 4:00 AM on May 26, 1992 at Cape Elizabeth, ME of 139 ppb appears erroneous when viewed in spatial and temporal context. As the top map in Figure 5-7 shows, no other site in the vicinity reported concentrations as high as 50 ppb much less near 139 (NESCAUM, 1992). Because the plot is by day (x-axis), the strong diurnal (cyclic) pattern of the temporal plot is apparent. There is an obvious detectable jump on the 26th even through the flowing pattern.

The top graph in Figure 5-8 show suspect values which practically jump out from the page as well as away from the rest of the data when displayed temporally (NESCAUM, 1992). Probably because these values (for the bottom picture) are well below the standard they went undetected. It appears they were from a misplaced decimal point as shown in the table as "# Before", "# In", and "# After".

Something as simple as the way points are labeled or marked can facilitate visual identification of an outlier. In Figure 5-9, the suspect calm wind is clearly marked differently than the stronger wind vectors (Main et al., 1995). This plot of surface winds on June 27, 1991 at 1900 shows that the calm wind in Bloomington is suspect when compared to the areas around it. Had there been other calm winds nearby, the wind velocity would be neither easily identifiable nor suspect.

5.3.4 Inter-Site Comparisons & Inter-Species Comparisons

Intersite and inter-species comparisons are important to identify similarities and differences. When site similarities are apparent (e.g., similar precursors are detected) similar control measures and predictors can be used. The example depicted in Figure 5-10 compares the Stafford, CT and E. Hartford, CT PAMS sites (Main et al., 1995). It contrasts the VOC composition at the two sites at 8:00 AM on June 3, 1994. While most other species behave similarly at the two sites, species #11 differs greatly. One possible explanation could be the influence of local sources. Alternatively, if the two sites were known to have previously had similar species #11 concentrations, then this reading might be suspect.

When two species are highly correlated, they might be dependent on one another. If so, neither species would be suitable for a prediction model that required linearly independent variables as predictors. The scatter plot matrix in Figure 5-11 illustrates the strong correlations between some VOC species for Stafford, CT during in June, 1995 (Main et al., 1995).

Figure 5-12 simultaneously compares two sites and two species: isoprene and m&p-xylenes for the PAMS sites at Stafford, CT and E. Hartford, CT (Main et al., 1995). Xylene concentrations act differently while isoprene behaved similarly at the two sites. Again, one explanation could be local emissions released at those times when the patterns are different.

5.4 REFERENCES

Cox, W.M. "A Workbook for Exploratory Analysis of PAMS Data." June 1995.

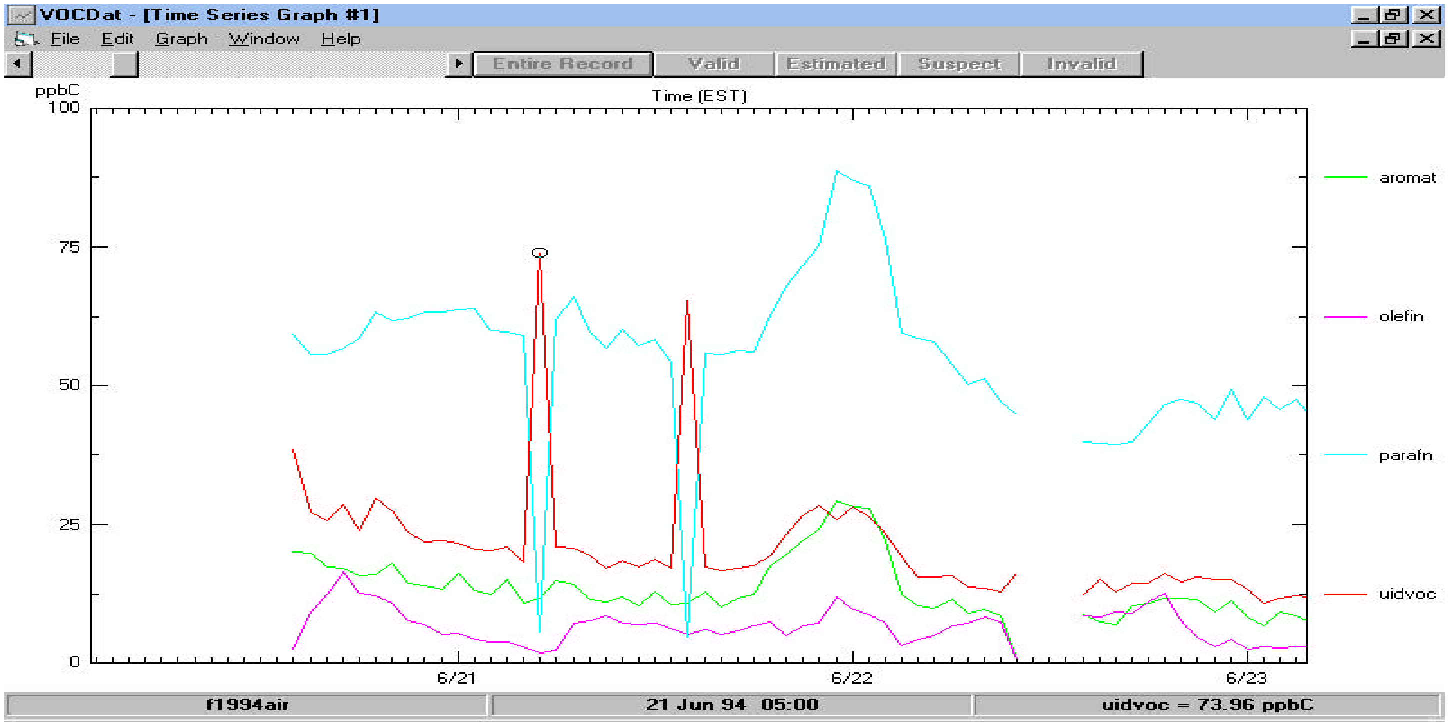
Main, H.; Roberts, P.; and Korc, M. Analysis of PAMS and NARSTO Northeast Data Supporting Evaluation and Design of Ozone Control Strategies: A Workshop. U.S. EPA Contract 68D30030, Sonoma Technologies, Inc., July 1996.

Northeast States for Coordinated Air Use Management (NESCAUM), The Ambient Monitoring and Assessment Committee. Preview of 1994 Ozone Precursor Concentrations in the Northeastern U.S. August 1995.

Northeast States for Coordinated Air Use Management (NESCAUM), The Ambient Monitoring and Assessment Committee. 1992 Regional Ozone Concentrations in the Northeastern United States. November 1993.

U.S. Environmental Protection Agency. Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Ambient Air Specific Methods (Interim Edition). EPA/600/R-94/038b, 1994.

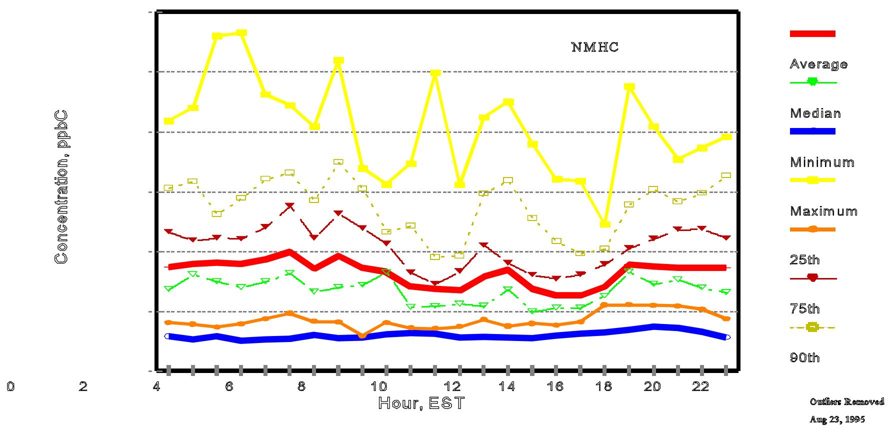
Figure 5-1.



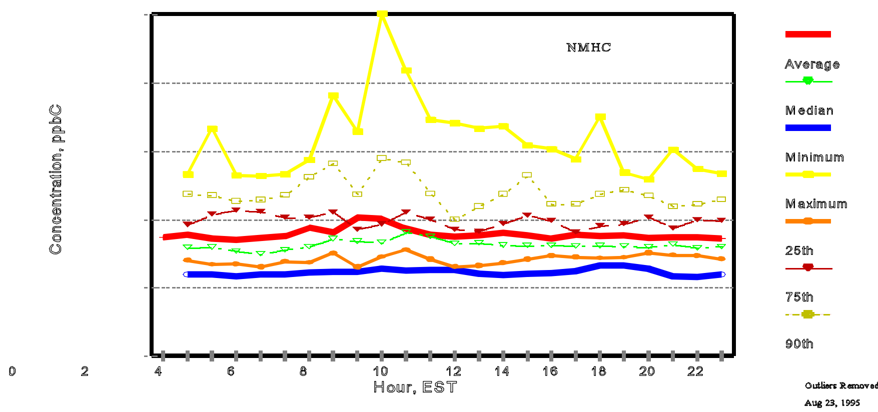
Time series plot of several species groups at Stafford, CT in 1994. Example of misidentification of a paraffin for an unidentified peak. (Level 0, preliminary data, CT DEP)

Figure 5-2.

E. Hartford, CT
June, 1995

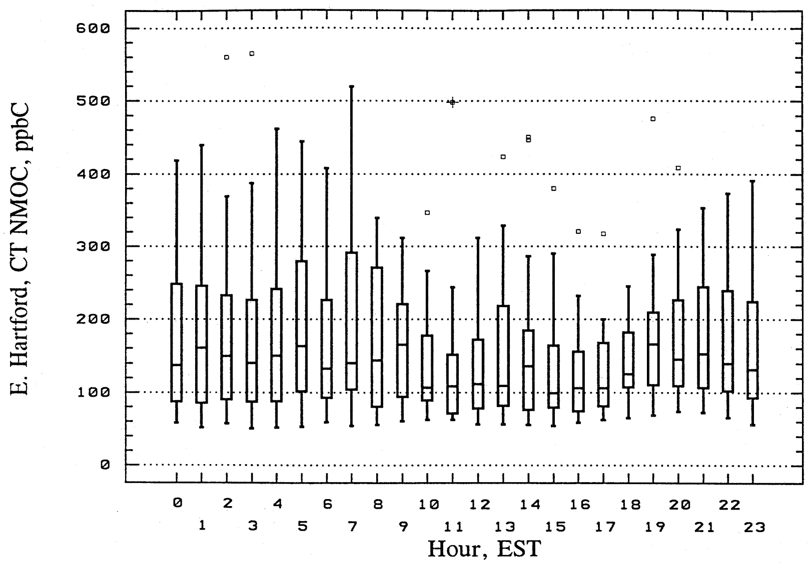


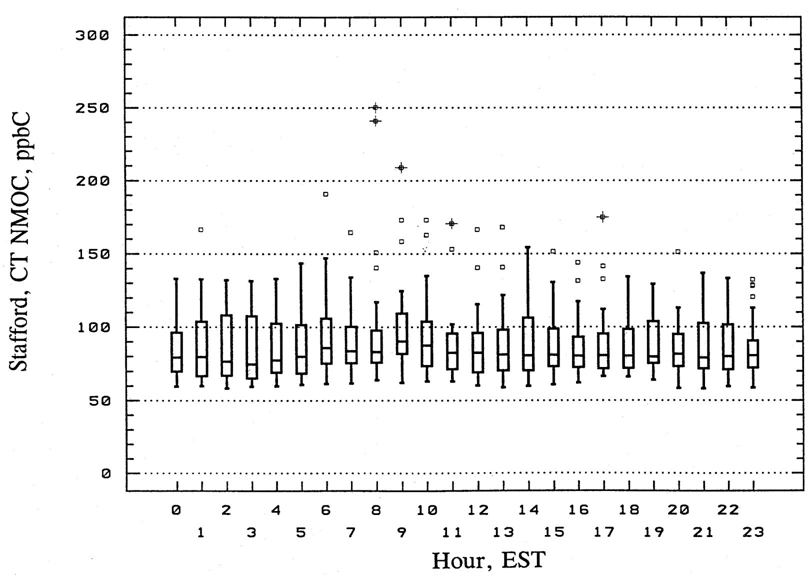
Stafford, CT
June, 1995



Summary statistics plotted for East Hartford and Stafford, CT for June 1995.
(Level 0, preliminary data, CT DEP)

Figure 5-3.





Box plots of NMOC by time of day during June 1995 at East Hartford, CT (top) and Stafford, CT (bottom). Concentrations varied widely at East Hartford.

Figure 5-4.

BALTIMORE PAMS DATA 1993

DATA COMPLETENESS

NUMBER OF HOURS PER DAY AVAILABLE

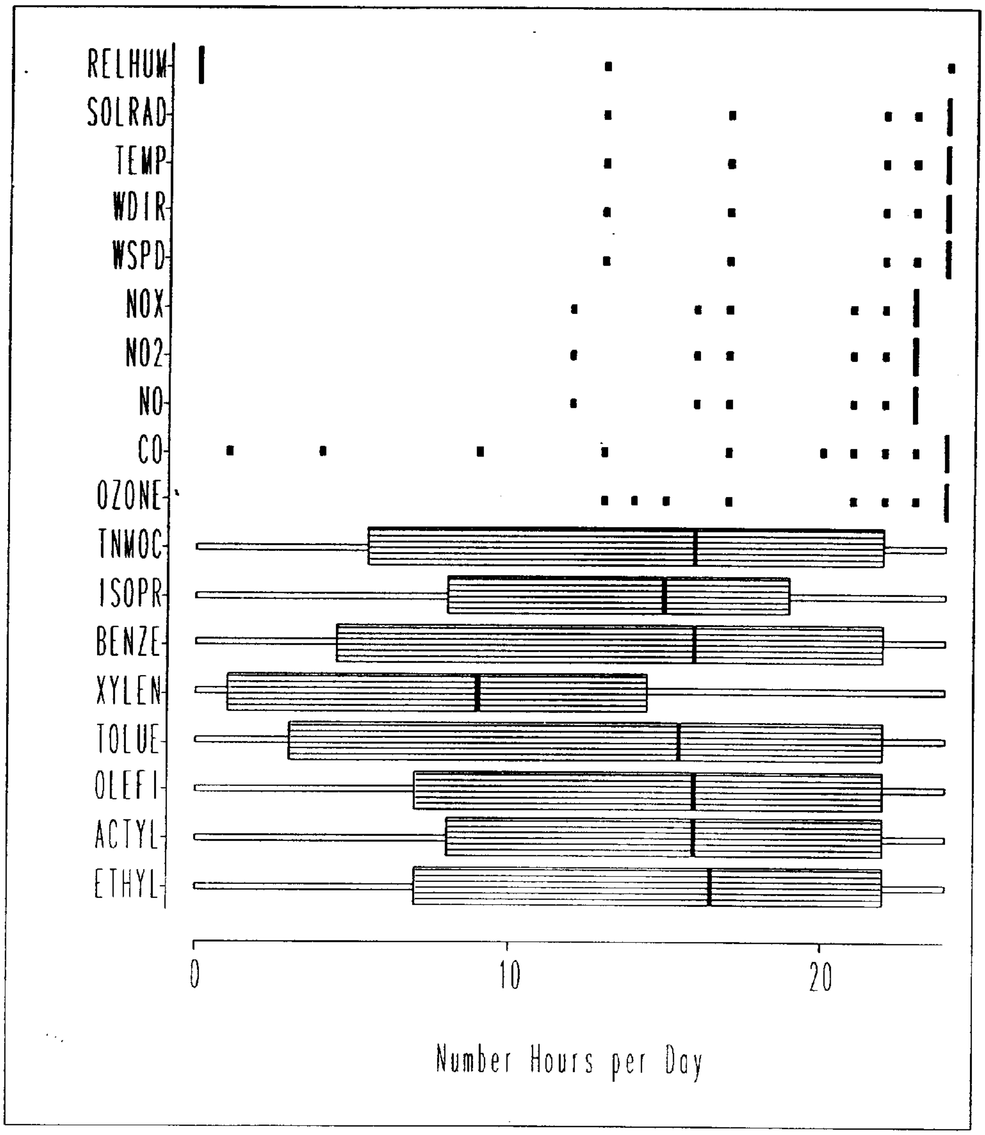


Figure 1

Figure 5-5.

DISTRIBUTION OF MISSING VALUES
FOR ETHYLENE AT BALTIMORE PAMS SITE
DAY AND HOUR OF DAY FOR JULY 1993

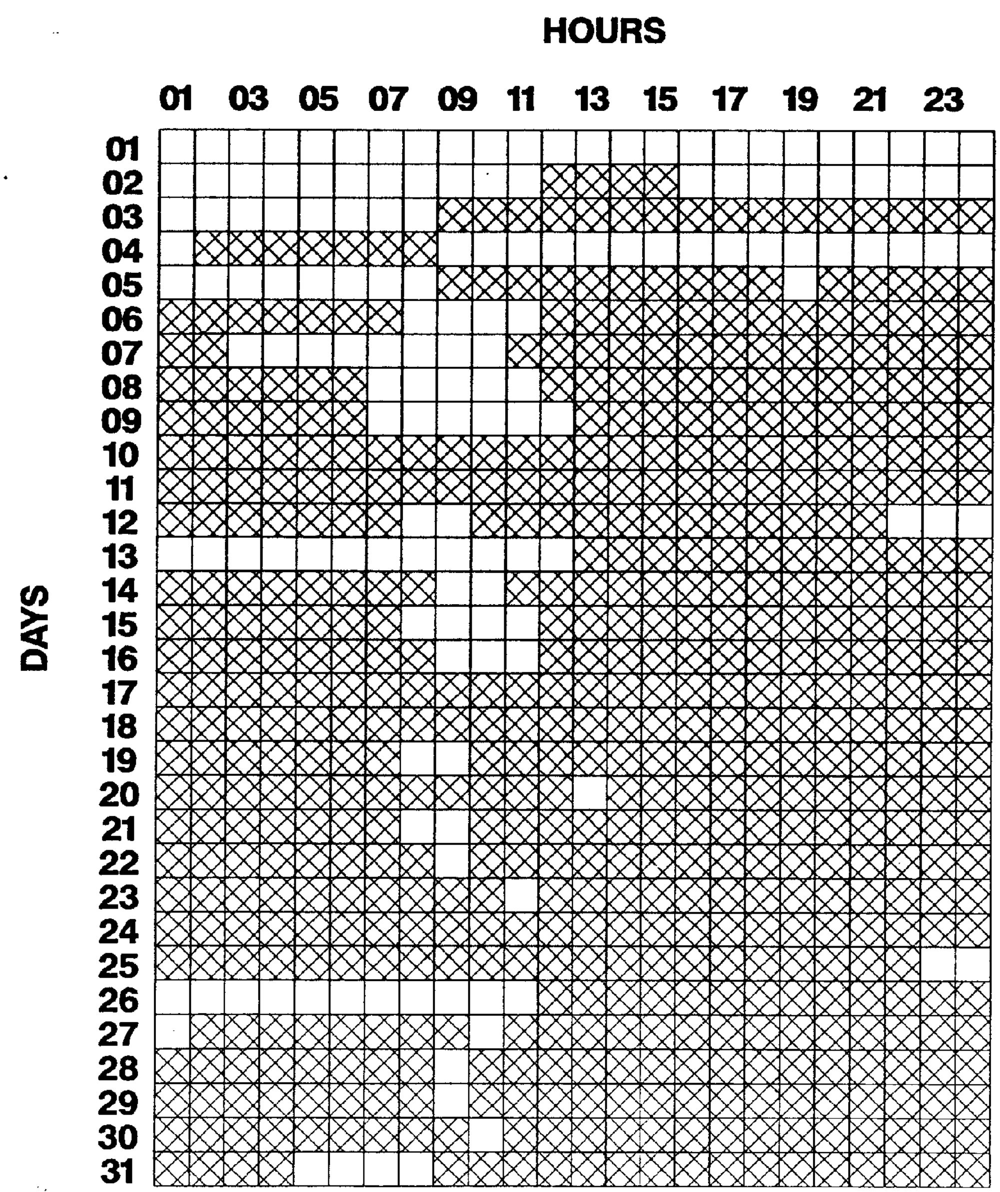
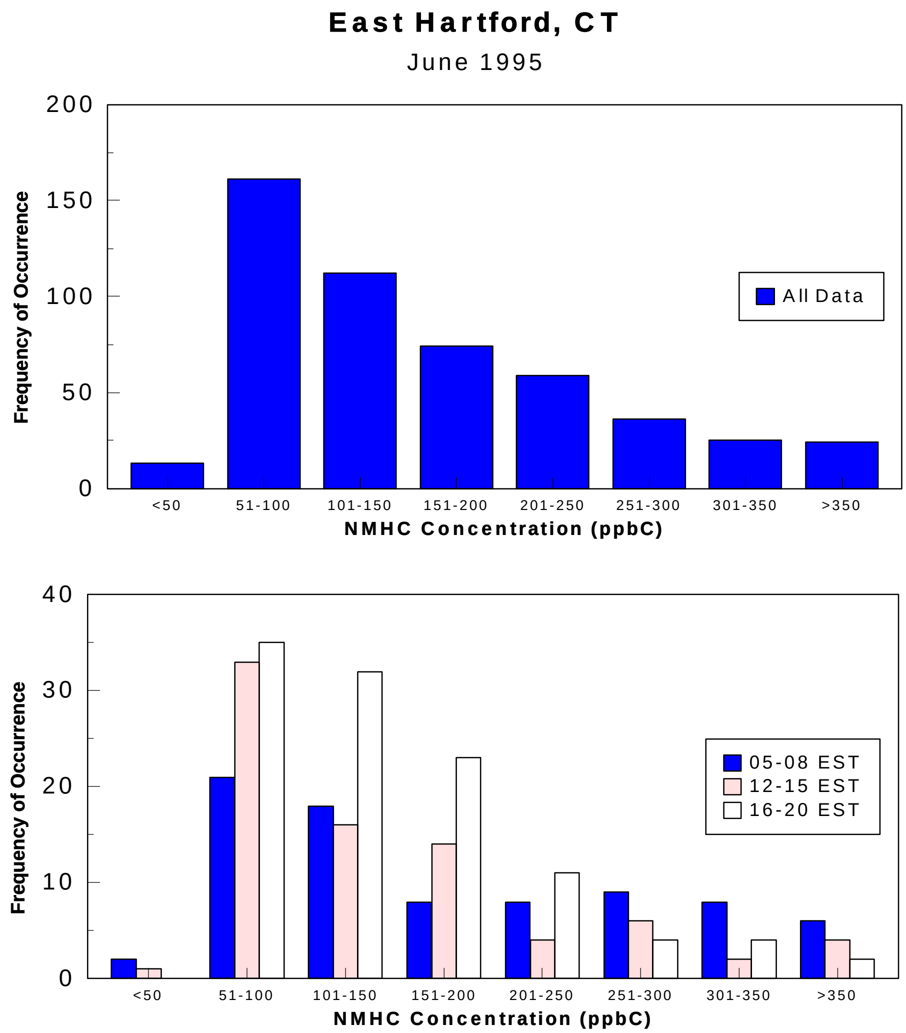


Figure 5-6.



Frequency distributions of total NMHC concentrations at East Hartford, CT for June 1995. Few data were below 50 ppbC; most data collected between 1600-2000 EST were 51 to 200 ppbC. (Level 0, preliminary data, CT DEP)

Figure 5-7.
Example of identification of suspect data values from the Northeast (NESCAUM 1993). The ozone concentration of 139 ppb reported at Cape Elizabeth, ME on May 26, 1992 at 4:00 AM appears erroneous when viewed in a spatial and temporal context.

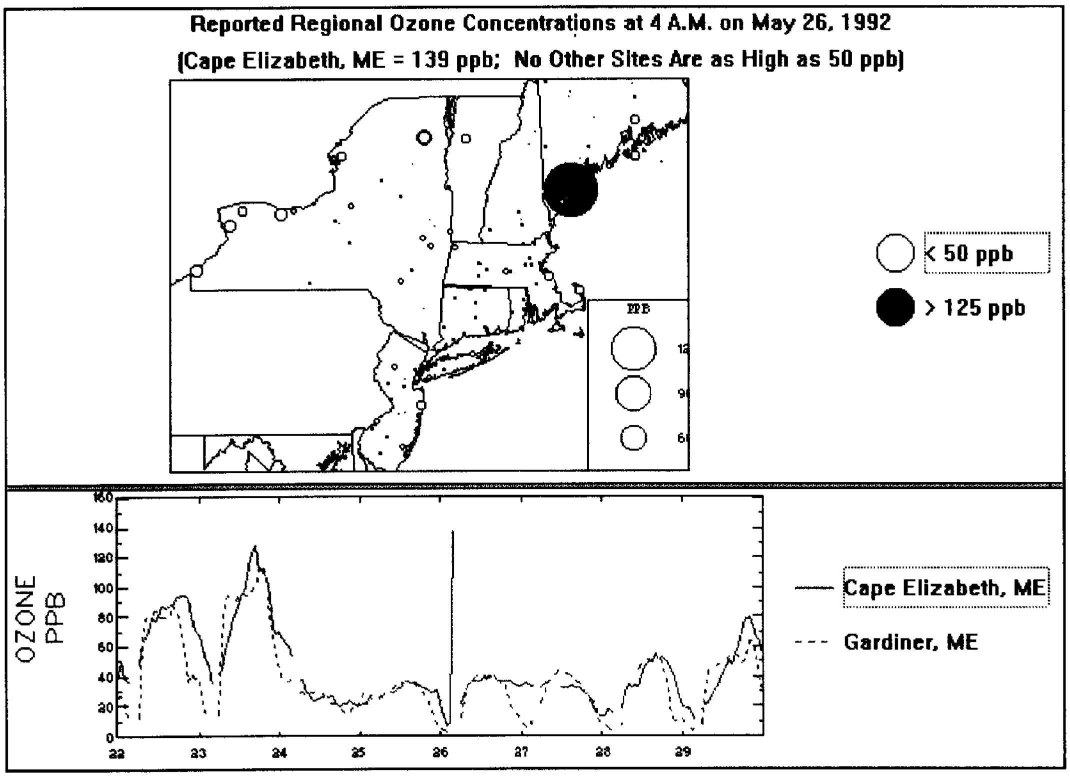
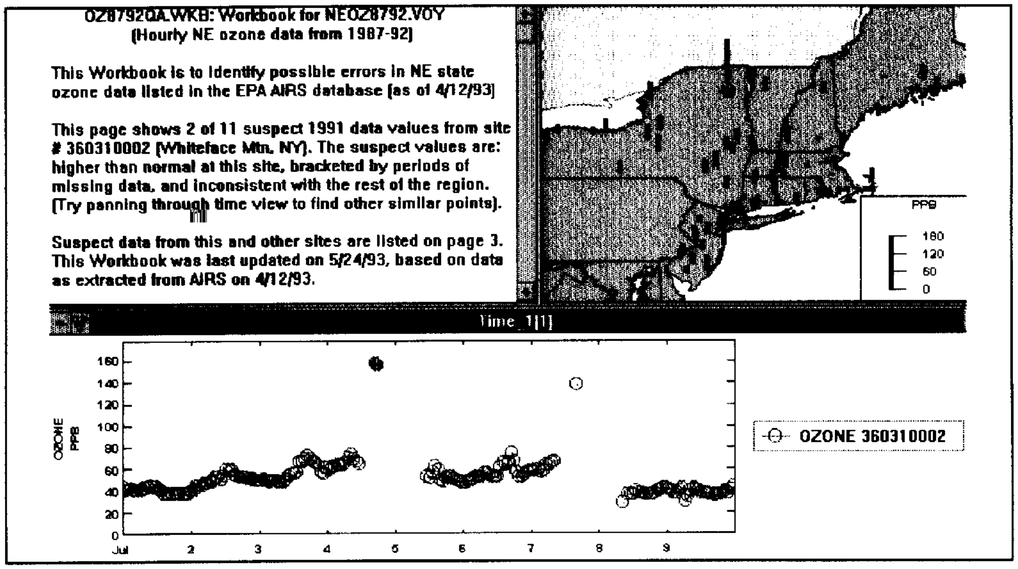


Figure 5-8.



The OZ8792QA.WKB workbook is dynamic - subject to continual revision as additional suspect data points are identified. Ultimately, these points are reported back to the original data generating state agencies - which can flag alter or eliminate the suspect data points from AIRS.

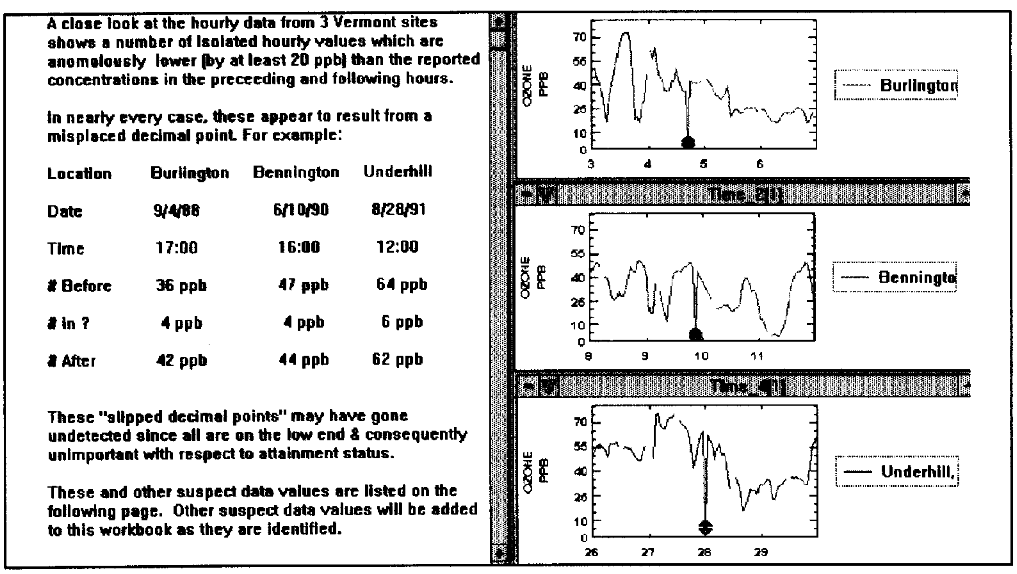
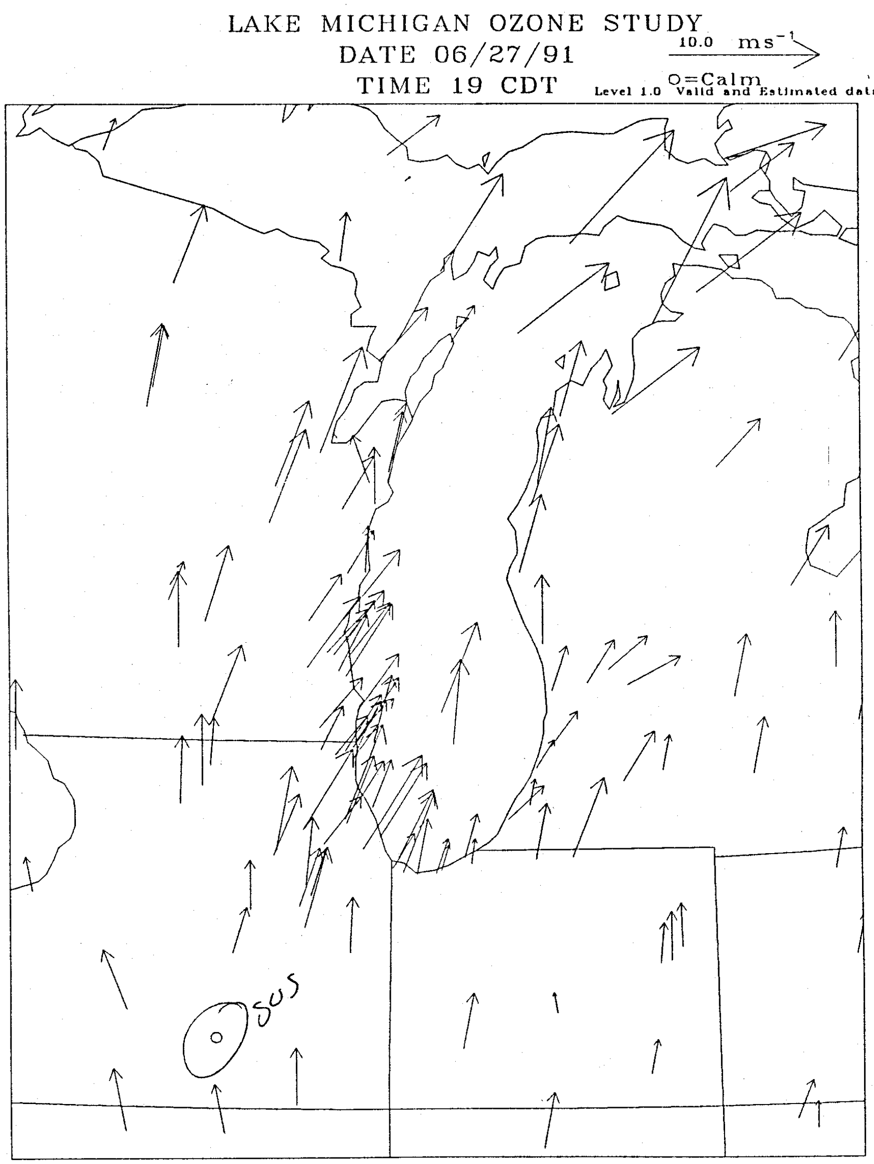
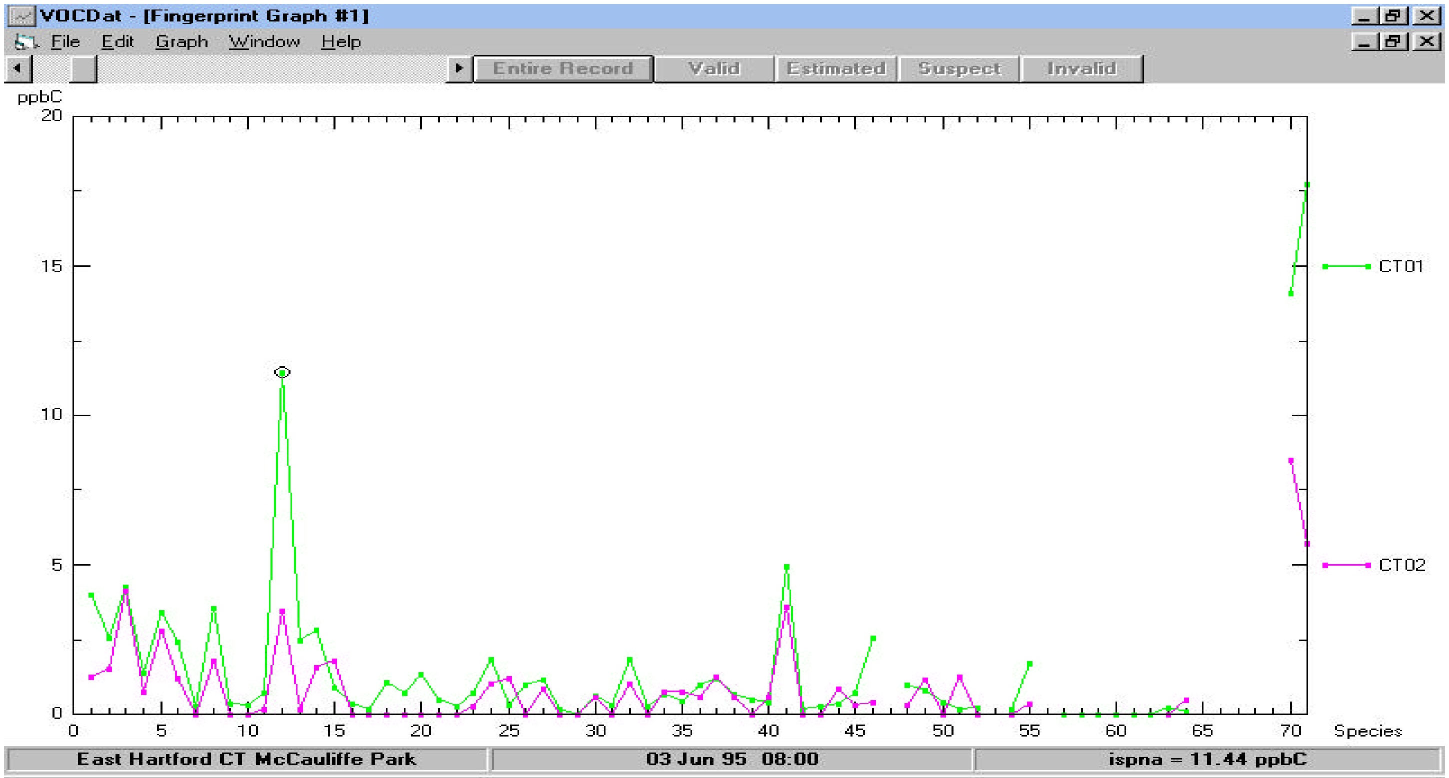


Figure 5-9.



Plot of surface winds on June 27, 1991 at 1900 CDT. The calm wind at Bloomington, Illinois was identified as suspect (SUS) during the data validation process. (Roberts et al., 1993)

Figure 5-10.



Fingerprint plot of June 3, 1994 at 0800 EST for Stafford and East Hartford, CT. This plot illustrates some of the differences between composition at the two sites. (Level 0, preliminary data, CT DEP)

Table 5-1. 90% Probability Limits for PAMS Target VOCs and Carbonyls Established by the 1993/1994 Proficiency Studies.

COMPOUND	AVERAGE BIAS	LOWER LIMIT	UPPER LIMIT
Ethylene	-13	-50	24
Acetylene	-9	-40	22
Ethane	-12	-35	11
Propylene	4	-27	35
Propane	-9	-40	22
Isobutane	-9	-34	16
1-Butene	-7	-44	30
n-Butane	-10	-34	14
trans-2-Butene	-6	-31	19
cis-2-Butene	-7	-29	15
3-Methyl-1-Butene	-6	-43	31
Isopentane	1	-29	31
1-Pentene	-6	-36	24
n-Pentane	-7	-29	15
trans-2-Pentene	4	-23	31
cis-2-Pentene	-9	-35	17
2-Methyl-2-Butene	9	-25	43
2,2-Dimethylbutane	-10	-33	13
Cyclopentene	-3	-24	18
4-Methyl-1-Pentene	-9	-42	24
Cyclopentane	-11	-35	13
2,3-Dimethylbutane	-5	-34	24
2-Methylpentane	-1	-28	26
3-Methylpentane	-6	-31	19
n-Hexane	-9	-30	12
trans-2-Hexene	-11	-42	20
cis-2-Hexene	-4	-30	22
Methylcyclopentane	-5	-32	22
2,4-Dimethylpentane	-8	-33	17
Benzene	-13	-37	11
Cyclohexane	-5	-29	19
2-Methylhexane	-3	-38	32
2,3-Dimethylpentane	-7	-31	17
3-Methylhexane	-7	-34	20
2,2,4-Trimethylpentane	-5	-31	21
n-Heptane	-8	-40	24
Methylcyclohexane	-3	-25	19
2,3,4-Trimethylpentane	-6	-33	21
Toluene	-1	-19	17
2-Methylheptane	-3	-32	26
3-Methylheptane	2	-21	25
n-Octane	-10	-47	27
Ethylbenzene	4	-35	43
mp-Xylene	12	-42	66
Styrene	-4	-67	59
o-Xylene	-1	-51	49
n-Nonane	-6	-26	14
Isopropylbenzene	4	-46	54
n-Propylbenzene	-11	-67	45
1,3,5-Trimethylbenzene	6	-53	65
1,2,4-Trimethylbenzene	-11	-59	37
Formaldehyde - low	0	-22	23
Formaldehyde - high	-2	-24	20
Acetaldehyde - low	1	-21	24
Acetaldehyde - high	-2	-25	20
Acetone - low	1	-22	23
Acetone - high	-6	-29	16

Table 5-2. 95% Probability Limits of Bias (Precision) for PAMS Ozone Monitors, 1995.

Area	Site Type	AIRS ID	Year lwr prb	Year upr prb	Q1 lwr prb	Q1 upr prb	Q2 lwr prb	Q2 upr prb	Q3 lwr prb	Q3 upr prb	Q4 lwr prb	Q4 upr prb
Boston	1	250051005	-3	4					-3	3	-2	4
	2	250092006	-10	8	-14	7	-9	2	-5	3	-3	13
	3	250094004	-6	4	-9	4	-4	1	-6	4	-4	6
	4	230052003	-5	2	-8	3	-5	1	-3	1	-4	1
Connecticut	2	090031003	-9	6			-11	4	-9	9	-2	2
	3	090131001	-7	3			-8	2	-3	3		
Portsmouth	2	230313002	-11	8			-9	11	-11	7	-12	5
Providence	1	090010017	-4	6			-5	4	-1	6	0	8
	2	440071010	-5	5			-2	2	-5	3	-7	11
	3	250051005	-3	4					-3	3	-2	4
Springfield	1	250130003	-10	7			-10	8	-11	4	-3	8
	2	250130008	-4	4	-7	7	-5	4	-3	3	-2	3
	3	250154002	-4	3			-4	5	-3	3	-3	0
New York	2	360050083	-6	6	-5	8	-9	7	-2	5	-3	2
Baltimore	1	240030019	-3	2	-2	1			-5	3	-3	3
	2	240053001	-4	2	-3	2	-3	1	-3	1	-5	3
	2	245100050	-4	4			-2	3	-6	5	-2	3
	3	240259001	-3	3			-3	5	-2	1	-3	2
	4	100031007	-10	11			-2	5	-14	13	-4	11
Philadelphia	1	100031007	-10	11			-2	5	-14	13	-4	11
	3	340210005	-4	4	-2	0	-5	4	-5	7	-4	4
Washington	1	510330001	-8	1			-9	-1	-6	1	-9	1
	3	240030019	-3	2	-2	1			-5	3	-3	3
	4	100031007	-10	11			-2	5	-14	13	-4	11
Atlanta	2	130890002	-6	4			-7	6	-6	1	0	2
	3	132470001	-1	11			-2	8	1	10	8	10
Lake Michigan	2	550790041	-6	3			-3	0	-6	6		
	2	170310072	-8	13			-13	15	-6	12	0	8
	2	180891016	-3	2			-4	2	-2	2		
	3	550890009	-8	8			-8	8	-9	9		
	4	170971007	-7	9	-21	0	-3	8	-4	8	-1	3
	4	550710007	-10	4			-3	4	-8	-3	-9	-2
Houston	2	482011035	-8	4	-11	0	-5	4	-4	5	-4	0
	2	482011003	-7	11	-2	17	-1	6	-8	6	-5	5
	3	482010024	-7	4	-5	2	-5	2	-11	8	-4	3
Baton Rouge	1	220330008	-3	10	-3	11	-3	7				
	2	220330009	-9	1	-6	0	-8	-3	-9	4	-8	0
	3	220470009	-5	7	-4	0	-1	8	1	7	-6	5
Beaumont	2	482450011	-6	10	-9	9	-2	12	-3	4	-4	7
El Paso	2	481410027	-8	2	-7	1	-6	1	-7	1	-11	5
	2	481410044	-12	13			-9	6	-9	16	-4	12
	3	481410037	-6	3	-4	1	-4	3	-3	0	10	4
South Coast/	2	060371601	-11	2	-11	-1	-11	0	-7	-5	-3	5
SEDAB	3	060370002	-7	4	-4	3	-5	6	-8	2	-7	6
	2	060650002	-16	25	5	19	-6	23	-2	13	-30	11
	4	060711004	0	7	-2	4	2	8	2	5	1	5
San Diego	2	060730003	-6	6	-8	6	-5	7	-5	7		
	2	060730006	-8	4	-6	2	-7	4	-10	6		
	3	060731006	-6	5	-7	6	-3	4	-8	7		
Ventura Co.	2	061113001	-4	9	-1	2	-5	7	-2	11	-1	8
	3	061112002	-11	8	-16	14	-8	2	-13	7	-3	2
Sacramento	2	060670006	-5	8	-3	10					-2	1
	3	060671001	-12	0							-12	0
San Joaquin	2	060290010	-8	4	-5	1	-11	0	-8	7	-6	4
	2	060195001	-4	3	-4	3	-1	4	-4	3	-4	0
	3	060295001	-10	4	-9	0					-10	7
	3	060194001	-3	5	-1	4	1	4	-5	4	-1	4

Table 5-3. 95% Probability Limits of Bias (Precision) for PAMS NO_2 Monitors, 1995.

	Site		Year		Q1		Q2		Q3		Q4	
Area	Type	AIRS ID	lwr prb	upr prb	lwr prb	upr prb	lwr prb	upr prb	lwr prb	upr prb	lwr prb	upr prb
Boston	2	250092006	-11	14	-2	12	-14	13	-2	14	-13	4
	3	250094004	-6	11	-2	14	-2	7	-11	8	-2	9
Connecticut	2	090031003	-9	9	-3	11	-13	13	-4	3	-8	3
	3	090131001	-10	2	-9	3	-11	2				
Portsmouth	2	230313002	-3	10					-3	10		
Providence	2	440071010	-9	3			-9	2	-8	3	-11	4
Springfield	1	250130003	-13	5							-13	5
	2	250130008	-16	13	-7	7	-10	13	-28	18	-14	7
	3	250154002	-17	6	-15	2	-14	4	-18	15	-14	-5
New York	2	360050083	-10	9			-13	5	-2	9	-8	4
Baltimore	1	240030019	-3	3			-4	3	-2	2		
	2	240053001	-4	7	-4	7	-5	7				
	2	245100050	-3	2			-5	3	-3	2	-3	3
	3	240259001	-4	5			-4	6	-4	4		
	4	100031007	-9	17	-6	10	-12	26	-8	13	0	10
Philadelphia	2	421010004	-6	5	-3	4	-7	6	-5	6	-6	6
	3	340210005	-6	7	-4	5	-4	3	-9	14	-5	3
Washington	1	510330001	-10	5	-7	6	-14	7	-7	2	-11	4
	3	240030019	-3	3			-4	3	-2	2		
	4	100031007	-9	17	-6	10	-12	26	-8	13	0	10
Atlanta	2	130890002	-15	9	-17	2	-10	0	-12	6	1	11
	3	132470001	-7	6	-8	2	-6	6	-7	9	-1	1
Lake Michigan	2	550790041	-8	7	-7	2	-6	8	-9	7	-8	11
	2	170310072	-17	9			-7	8	-19	7		
	2	180891016	-6	11	-2	6	-6	7	-7	7	-1	15
	3	550890009	-10	12			-13	13	-10	12		
	4	170971007	-7	15			-2	4	-6	20		
	4	550710007	-7	9			-9	9	-5	9		
Houston	2	482011035	-2	3	-3	4	-1	3	-3	4	-2	3
	3	482010024	-8	1	-4	0	-4	0	-11	1	-8	-2
Baton Rouge	1	220330008	-8	11	-11	10	1	8				
	2	220330009	-2	5	-2	3	-2	3	0	4	-2	8
	3	220470009	-2	8	0	6	-3	11	2	8	-2	5
El Paso	2	481410027	-13	7	-12	3	-9	0	-13	8	-13	5
	3	481410037	-12	8	-11	1	-8	3	-1	2	-18	19
South Coast/	2	060371601	-11	21	-21	18	-1	16	-6	10	3	24
SEDAB	3	060370002	-12	8	-8	-3	-11	5	-12	11	-9	15
	4	060711004	-5	18	-5	10	-3	14	-2	24	1	8
San Diego	2	060730003	-14	20	0	15	-14	26	-11	-2		
	2	060730006	-4	17	-6	18	4	18	-3	7		
	3	060731006	-4	13	-4	7	-3	18	-1	11		
Ventura Co.	2	061113001	-9	4	-5	3	-11	1	-7	2	-9	6
	3	061112002	-9	10	-11	9	-8	3	-9	13	-4	10
Sacramento	2	060670006	-4	14	-6	16					-3	14
	3	060671001	-9	10							-9	10
San Joaquin	2	060290010	-6	19	1	7	-7	5	9	15	13	15
	2	060195001	2	14	10	15	6	12	4	6	2	10
	3	060295001	-19	8	-16	-5					-13	12
	3	060194001	4	15	4	11	7	17	5	13	5	16